Caldera unrest management in New Zealand
What is caldera unrest?

Caldera volcanoes are formed by collapse during large, explosive eruptions

- Eruptions are low frequency, high impact events
- e.g. Taupo, Rotorua, Okataina

Even if there is no eruption, these volcanoes can be hazardous due to volcanic unrest.

Magma forcing its way through the ground beneath volcanoes produces signals which can be interpreted by scientists to help give warning of an eruption:

- earthquakes
- ground movement
- gas and hydrothermal changes
- other small signals recorded by monitoring equipment

Time series plot showing small scale elevation changes at Horomatangi Reef, Lake Taupo over the last 35 years
Potential physical consequences of caldera unrest

*Ground shaking from earthquakes*
- ranging from unnoticeable to damaging
- may cause liquefaction and landslides

*Ground deformation*
- uplift and subsidence of millimetres to metres per day

*Gas poisoning*
- potentially lethal in depressions

*Hydrothermal system changes*
- including potentially large steam explosions

Landslide from Taupo earthquake swarm, 1922 (note man for scale)
Likely social consequences of caldera unrest

Psychosocial
- public anxiety from months of earthquakes and uncertainty
- frustration and anger over economic impacts
- potential political consequences
- evacuations

Economic
Impacts on:
- tourism
- local and national economies
- insurance industry
- investment industries

Effects of misreporting on international tourism from Taupo earthquake swarm,
Evening Post, 13 July 1922
New Zealand caldera unrest episodes

New Zealand has experienced numerous caldera unrest episodes during historical times. A summary of the more severe unrest examples:

<table>
<thead>
<tr>
<th>Caldera name</th>
<th>Date of episode</th>
<th>Seismicity</th>
<th>Deformation</th>
<th>Hydrothermal/other</th>
<th>Social impact &amp; response</th>
<th>Eruption?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okataina</td>
<td>1886</td>
<td>Felt seismicity started only about 1 hour before the eruption</td>
<td>No surface deformation is known</td>
<td>No unusual hydrothermal activity was noted. New features formed post eruption.</td>
<td>Unknown impact during unrest; 108 died in eruption</td>
<td>Yes</td>
</tr>
<tr>
<td>Taupo</td>
<td>1895</td>
<td>M6 to M7.5 with 6 weeks of frequent aftershocks felt; liquefaction</td>
<td>Landslips; fissures; unknown if subsidence or uplift</td>
<td>0.6 m tsunami in lake; spring temperature changes</td>
<td>Chimneys collapsed; minor injuries; anxiety; self-evacuations</td>
<td>No</td>
</tr>
<tr>
<td>Taupo</td>
<td>1922</td>
<td>Thousands of earthquakes, max M6 over 10 months</td>
<td>Subsidence of 3.7 m at Whakaipo Bay; faulting; liquefaction</td>
<td>Changing hydrothermal activity at Mokai, Orakei Korako, Wairakei</td>
<td>Chimneys collapsed; tourism effected from misreporting; self-evacuations</td>
<td>No</td>
</tr>
<tr>
<td>Raoul Island</td>
<td>2006</td>
<td>5 days of earthquakes distant to volcano</td>
<td>No deformation recorded</td>
<td>No unusual hydrothermal changes</td>
<td>One fatality during eruption</td>
<td>Yes</td>
</tr>
</tbody>
</table>

International examples of caldera unrest

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<th>Eruption?</th>
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<tr>
<td>Campi Flegrei (Italy)</td>
<td>1982-1984</td>
<td>Hundreds of felt earthquakes, some large (&lt;M4.2).</td>
<td>3.5 m uplift</td>
<td>Gas concentration increases</td>
<td>40,000 evacuated, damaged buildings</td>
<td>No</td>
</tr>
<tr>
<td>Long Valley (U.S.)</td>
<td>1979-1984</td>
<td>Swarms between 1982-4, 3 M6 quakes in 1 day</td>
<td>25 cm uplift in &lt;6 months</td>
<td>No confirmed hydrothermal changes</td>
<td>Anger and frustration; economic effect; political impact</td>
<td>No</td>
</tr>
</tbody>
</table>
The Caldera Advisory Group (CAG)

An interagency collaboration focusing on increasing the understanding of caldera unrest episodes, risks and potential consequences.

Outputs to date include:

- The Caldera Unrest Management Sourcebook\(^1\)
- Multiple scenarios to aid the development of the Group, and to assist in facilitating the participation of a wider group of organisations potentially involved in caldera unrest management
- A strategic work plan

The Caldera Advisory Group (CAG)

Agencies involved include:

- Bay of Plenty Regional Council
- Waikato Regional Council
- Bay of Plenty Civil Defence Emergency Management Group
- Waikato Civil Defence Emergency Management Group
- Ministry of Civil Defence and Emergency Management
- GNS Science
- Rotorua District Council
- Taupo District Council

A wider group will meet regularly to discuss caldera unrest related issues.

CAG is primarily a strategic planning group with no operational or response function at this time. A range of mitigation measures will be investigated.
The Caldera Advisory Group (CAG) work plan

Caldera Advisory Group Work Plan

<table>
<thead>
<tr>
<th>Short term</th>
<th>Medium term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAG Formation</td>
<td>Facilitate interagency communication</td>
<td>Caldera unrest risk reduction strategy</td>
</tr>
<tr>
<td>Identify risks related to caldera unrest</td>
<td>Create risk mitigation strategy</td>
<td>Caldera unrest response strategy</td>
</tr>
<tr>
<td>Scenario development</td>
<td>Identify information and monitoring needs from GeoNet</td>
<td>Caldera unrest recovery strategy</td>
</tr>
<tr>
<td>Strategic Action Plan</td>
<td>Create communication strategy</td>
<td></td>
</tr>
<tr>
<td>Communication/education strategy</td>
<td></td>
<td></td>
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<tr>
<td>Create research strategy</td>
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</tbody>
</table>

Understanding of risks:

Reduction / Readiness / Response / Recovery

Developing mitigation strategies
Caldera unrest summary

Caldera unrest

• may involve earthquakes, ground deformation, hydrothermal (steam) explosions and/or gas emissions
• is much more frequent than eruptions
• may last for days to decades
• may be physically dangerous
• can cause wide reaching effects, including on the psychological health of nearby communities and the economy
• is monitored by GeoNet at GNS Science

This unique hazard needs to be proactively planned for now.

The Caldera Advisory Group (CAG) is a recently formed interagency strategic planning group focusing on increasing the understanding of caldera unrest episodes, risks and potential mitigation measures.

For more information on caldera unrest, see: